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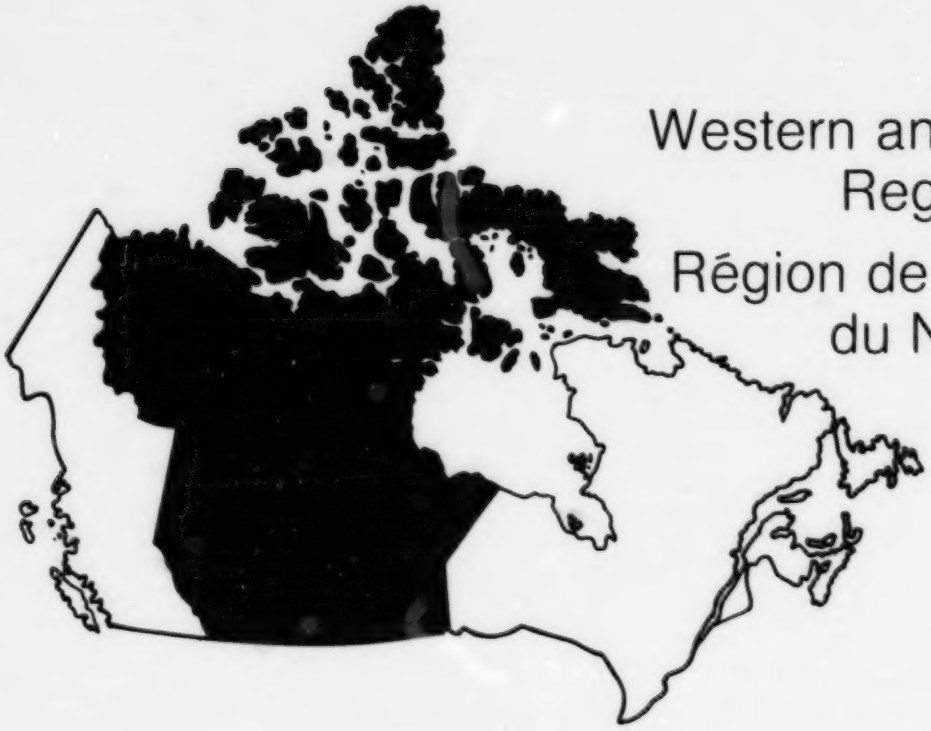

Western and Northern Region

Région de l'Ouest et du Nord

Environmental Protection

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Canada

SELECTION OF AN AREA IN THE CANADIAN BEAUFORT SEA FOR DISPOSAL OF INERT BULKY MATERIALS SUCH AS SCRAP METAL: AN ASSESSMENT OF OPTIONS

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SELECTION OF AN AREA IN THE CANADIAN BEAUFORT SEA FOR DISPOSAL OF INERT BULKY MATERIALS SUCH AS SCRAP METAL: AN ASSESSMENT OF OPTIONS

ENVIRONMENTAL PROTECTION
CONSERVATION AND PROTECTION
ENVIRONMENT CANADA
YELLOWKNIFE, N.W.T.

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SUMMARY AND RECOMMENDATIONS

The purpose of this project was to assess the possible biological, physical environmental, legislative, and industrial constraints which might affect the designation of a bulky inert waste ocean disposal site in the Canadian Beaufort Sea, and based on this analysis, to recommend one or more preferred dumpsite locations. In conjunction with this objective, information regarding the possible ocean dumping requirements of northern businesses and the alternate modes of transport of wastes were examined.

A decision matrix was used to determine which regions of the Beaufort Sea could be considered as "Acceptable (A)", "Potentially Acceptable (P)" or "Unacceptable (U)" as areas within which dumpsites could be selected. The screening of areas was based on a review of the nature, quantities and sources of wastes to be dumped, the factors affecting dumpsite selection (including biotic populations, pertinent climatological and oceanographic features, ecological features, government legislation and policies, oil and gas development, shipping, and other uses of the sea) and the effects of ocean disposal of bulky inert wastes.

For wastes stockpiled at Tuktoyaktuk, the closest "Acceptable" ocean disposal areas would be located approximately 160 km away in either Block 21 or 26, although two "Potentially Acceptable" areas, Blocks 20 and 25, are closer (120 and 115 km respectively). The northern, deeper portions of either Block 20 or 25 have no constraints to their selection as ocean disposal areas. The approximate cost per trip to the "Acceptable " blocks is estimated at $43,000, and would be decreased to $37,000 - 38,000 if one of the "Potentially Acceptable" ocean disposal areas were ultimately selected.

The closest "Acceptable" disposal area from King Point is Block 8, which is located 50 km to the NNE from this site on the Yukon coast. Several other "Acceptable" (Blocks 9 and 16) and "Potentially Acceptable" (Block 4, 5, 10, 15 and 20) areas are located within 170 km of King Point. Depending on which area is selected for ocean disposal, the round-trip costs to the blocks indicated above would range from about $28,000 to $45,000.

It is recommended that dumping take place from a barge or oilfield supply vessel during the open-water season. The material should be carefully released from a stationary vessel to minimize the zone of impact, and all subsequent loads should be dumped to the side to ensure that the material does not pile up to the extent that a navigational hazard is created.

It is recommended that a study be conducted to characterize the physical and biological environment of any "Acceptable" or "Potentially Acceptable" area or areas considered further for ocean dumping of inert wastes in the Beaufort Sea. This study is considered necessary because of the lack of site-specific data in almost all offshore areas of the Beaufort, and will provide the baseline for comparison of pre- and post-dumping environmental conditions and quantification of the actual impact of ocean dumping.

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1. INTRODUCTION

1.1 The Ocean Dumping Control Act

The disposal of wastes in Canadian marine territorial waters is regulated by the Ocean Dumping Control Act (ODCA). The Act is administered by Environmental Protection (EP), Conservation and Protection, Environment Canada. Under the ODCA, a permit system (Section 3.11) is used to regulate the disposal of wastes at sea, including the placement of material on ice or its destruction at sea by fire or heat. The Act also applies to the loading of wastes onto ships, aircraft, platforms or other man-made structures for subsequent ocean disposal. The terms and conditions of each permit vary with the type of substance being dumped, and are designed to protect human health, marine biota and other uses of the sea.

EP carries out its ODCA mandate with advice from the Regional Ocean Dumping Advisory Committee (RODAC) of the region where the dumping is to occur. In the Canadian Beaufort Sea, the review of applications for permits is coordinated by the EP Northwest Territories District Office in Yellowknife when the dumping is to occur in marine waters adjacent to the Northwest Territories; the EP Yukon Branch in Whitehorse is the focal point for the review of applications for dumping in marine waters off the Yukon Territory. Arctic RODAC provides advice to EP/NWT, whereas the Pacific Region RODAC advises EP/YT. The RODAC for the two Beaufort Sea jurisdictions includes representation from EP and the Department of Fisheries and Oceans (DFO). Arctic RODAC in the NWT also includes representation from the Canadian Wildlife Service (CWS), Indian and Northern Affairs Canada (INAC), the Renewable Resources Department of the Government of the Northwest Territories, and the Canada Oil and Gas Lands Administration (COGLA). The duties of RODAC include reviewing and assessing permit applications; identifying and drafting the terms and conditions to be incorporated into permits; and advising the respective District Managers regarding monitoring, inspection, research, analysis and enforcement procedures pertaining to permitted ocean dumping activities as defined in the ODCA. On the advice of RODAC, ocean dumping permits for the NWT are approved by the EP Western and Northern Regional Director in Edmonton, Alberta, whereas Yukon permits are approved by the EP Pacific and Yukon Regional Director in Vancouver, British Columbia. A Beaufort Sea RODAC is being established in Inuvik to handle applications pertinent to both jurisdictions to ensure that local concerns are known and that the ODCA is administered in a consistent manner.

An important goal of EP in administering the ODCA is to promote a planned approach to waste management in the Canadian Beaufort Sea area. A decision-making process based on sound regional planning is the ultimate objective of EP in this regard, where a variety of disposal options are in place and available for use as appropriate. EP is conducting this exercise to ensure that a properly planned ocean disposal strategy is in place to avoid the possible proliferation of small dumpsites established on an ad hoc basis.

Alternatives to ocean disposal are examined each time an ocean dumping permit application is reviewed. The primary alternatives to ocean disposal of bulky inert wastes are continued storage or transport in barges to the south, where scrap metal could be sold for salvage. From an industry viewpoint, the former has generally been the most acceptable waste disposal option to date. Although the cost of barging scrap metal south may be partially off-set by the return gained through its subsequent sale, there is no such gain for non-salvagable wastes, thereby increasing the attactiveness of ocean disposal from an economic perspective.

1.2 The Purpose and Scope of the Project

1.2.1 Purpose

This study was undertaken as Phase II of a multi-phase project to assess the suitability of potential open-water waste disposal areas in the Canadian Beaufort Sea for scrap metal and other bulky inert solids. Phase I consisted of an investigation (Dillon Ltd., 1983) and a workshop (Thomas, 1984) on the feasibility of locating such ocean disposal areas. Phase III is expected to consist of a series of meetings with residents of local communities, industry, and other government agencies to obtain a consensus regarding the selection of a site which can then be identified in approved ocean dumping permits. This report, together with the opinions obtained during the Phase III meetings, will be presented to the Arctic RODAC. This committee will then recommend an ocean disposal area (or areas) to the EP Regional Directors, who have the responsibility for approval of permit applications.

1.2.2 The Study Area

The study area is shown in Figure 1 and encompasses that portion of the Canadian Beaufort Sea south of the 1000 m isobath or the approximate location of

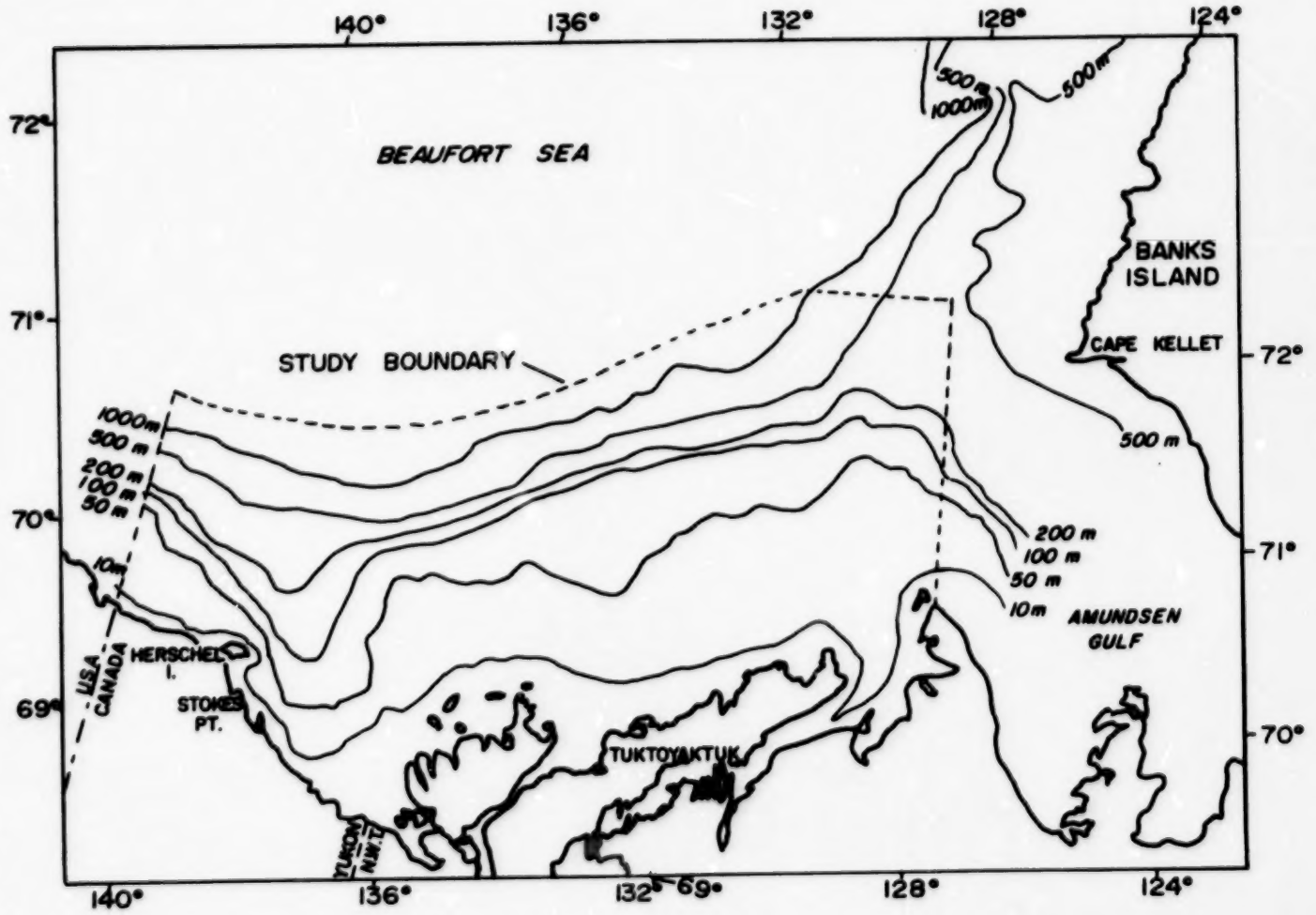

Figure 1. Study Area.

the permanent polar pack ice. Its western boundary is a seaward extension of the Alaska/Yukon border. A line north from Cape Bathurst represents the eastern boundary of the study area.

1.2.3 Study Objectives

Given the dumpsite selection criteria established in Phase I, the objectives of the present study (Phase II) were to:

1. assess areas of the Canadian Beaufort Sea with regard to constraints that might affect their suitability for the disposal of bulky inert wastes;
2. recommend one or more areas where ocean disposal of scrap metal and other solids appears feasible;
3. compile data from northern businesses regarding their possible ocean dumping requirements;
4. recommend the most economical and suitable modes of transport of wastes to selected disposal areas;
5. determine if dumping would cause more or less damage to the environment if confined or dispersed; and,
6. outline a pre-dumping assessment or post-dumping monitoring program to assess the environmental effects of dumping scrap metal and other inert solid wastes in one or more of the recommended disposal areas.

2. NATURE OF THE WASTES

2.1 Types of Materials

The scope of this study has been limited to the disposal of scrap metal and other bulky inert wastes. "Inert" wastes were defined in the workshop held in Phase I of this project (Thomas, 1984) as substances for disposal which are generally unreactive. Inert materials have very limited chemical and biological reactivity and, therefore, their rate of reaction in the environment and reaction products cause no meaningful environmental change. For purposes of this report, bulky inert wastes include scrap metal (such as scuttled aircraft, ships, automobile bodies, snowmobiles, drill pipe, casing, rods etc.) and miscellaneous industrial wastes (e.g., rubber tires and concrete).

"Bulky" materials are defined as solids greater than 0.5 cm in their largest dimension (i.e., the gravel particle size category). In general, bulky wastes (such as scrap metal or concrete) are expected to fall directly to the sea floor when dumped and remain in one location.

2.2 Sources of Materials

Types and approximate quantities of inert wastes generated annually by industry in the Beaufort Sea region are summarized in Table 1A. Materials that are presently in storage and may be considered for ocean disposal in the future (EP, unpublished data) are identified in Table 1B. These data were compiled through on-site observations and interviews with industry personnel at each site, as well as in the Calgary offices of the oil companies. They are believed to reflect accurately the present types and quantities of inert wastes in the region.

Table 1.

Environmental Protection Service 1983 Inert Waste Survey Data (EPS, unpubl. data).

A. Waste Generated Annually

Company	Type of Waste	Generation Rate/Year	Frequency of Disposal	Present Disposal Site	Ownership of Present Site	Treatment and/or Shipping Method prior to Disposal	Options in Addition to Ocean Disposal
Dome Petroleum Limited	1) scrap metal	-	as required	Tuk-Base yard	Dome	none	storage
	2) empty 45-gal drums	-	-	Tuk-Base yard	Dome	-	storage
Esso Resources Canada Limited	A. Present (Exploration)						
	1) scrap metal	300 tonnes/year	once/year	Hay River scrap dealership	Hay River scrap dealer	barged from Tuktoyaktuk to Hay River (1984)	as at present
	2) empty 45-gal drums and other small scrap metal wastes	-	once/year	Esso Base yard Tuktoyaktuk	Esso	crushed	buried in landfill site
	B. Future (Production)						
	1) scrap metal	100 tonnes/year	-	-	-	-	-
BeauDril Limited (subsidiary of Gulf Canada Resources Inc.)	1) scrap metal (wire rope, etc.)	250 tonnes/year	-	BeauDril yard, Tuktoyaktuk	BeauDril	-	storage
Northern Transportation Company Limited (NTCL)	1) scrap metal (steel cables, etc.)	-	once/year	Hay River scrap dealership	Hay River scrap dealer	barged to Hay River	as at present
Arctic Transportation Limited (ATL)	1) scrap metal (wire rope)	1 tow line/year	as required	ATL yard, Tuktoyaktuk	ATL	cut up	storage

B. Waste Presently in Storage

Company	Type of Waste	Quantity	Present Disposal Site	Ownership of Present Site	Treatment and/or Shipping Method	Options
Dome Petroleum Limited	1) scrap metal	500 - 1,000 tonnes	Tuk-Base yard	Dome	none	-
	2) empty 45-gal drums	-	Tuk-Base yard	Dome	-	-
Esso Resources Canada Limited	1) scrap metal	> 150 tonnes/ in past	Hay river scrap dealership	Hay River scrap dealer	barged to Hay River	-
	2) sump and part of a derrick	-	Esso Base yard Tuktoyaktuk	Esso	none	-
BeauDril Limited (subsidiary of Gulf Canada Resources Inc.)	1) wire rope	150 tonnes	BeauDril yard, Tuktoyaktuk	BeauDril	none	-
	2) empty 45-gal drums	50 c-cans	BeauDril yard, Tuktoyaktuk	BeauDril	crushed; placed in c-cans	-
	3) Tarsiut Island caissons	-	Herschel Basin	-	-	-
	4) other scrap metal	250 tonnes	BeauDril yard, Tuktoyaktuk	BeauDril	none	

3. FACTORS AFFECTING OCEAN DUMPSITE SELECTION

The final decision regarding the selection of one or more areas for ocean disposal of inert wastes must be based on a knowledge of a wide variety of factors. The ultimate goal is to select areas where dumping of scrap metal and other bulky wastes will: (1) cause the least impact on biota, oceanographic features and seafloor characteristics; (2) meet all of the requirements set out in government legislation and policy; (3) be economically viable for the companies and groups that have a need to dispose of such wastes; and (4) not interfere with oil and gas exploration activities, shipping and other uses of the Beaufort Sea.

The primary biological resources of the Beaufort Sea that could be affected to a greater or lesser degree by ocean dumping activities are zoobenthos, fish, marine birds and marine mammals. A substantial amount of information on the distribution, abundance, migrations or movements, and life history of biological resources in the Beaufort Sea region has been obtained over the last two decades. Much of the basic research and monitoring conducted in the area has been a result of requirements and concerns related to industrial development in the Beaufort Sea. Biological information collected prior to 1982 was summarized in the Beaufort Sea - Mackenzie Delta Environmental Impact Statement (Dome Petroleum et al., 1982a, b) and one of its major Support Documents, "A Biological Overview of the Beaufort and Chukchi Seas" (LGL and ESL, 1982). Since this date, research has continued to focus on many of the high-profile species in the region and has been carried out by government, academic, private and industry scientists. Although it is beyond the intended scope of this report to describe the biological environment of the Beaufort Sea, those species and communities which are most likely to be affected by ocean disposal of scrap metal and other bulky inert wastes are identified in later sections describing the environmental effects of this activity (Section 4) and application of biological constraint criteria to ocean dumpsite selection (Section 6).

Oceanographic features and seafloor characteristics also have a bearing on the selection of the most appropriate areas for location of dumpsites, particularly ice features and bathymetry. As with biological resources, there has been a substantial research effort directed at characterization of the physical setting of the Beaufort Sea region, in many cases because of the need for such information in conjunction with petroleum industry activities. This background information has not been summarized in this report, although physical constraints in the selection of the most suitable areas for disposal of scrap metal and other bulky wastes are discussed later in Section 6.

Other factors influencing ocean dumpsite selection are discussed in the following sections.

3.1 Government Legislation and Policies

A variety of government legislation and policies influences the selection of potential ocean dumpsites in the Beaufort Sea. These include the Ocean Dumping Control Act, the Arctic Waters Pollution Prevention Act, the Navigable Waters Protection Act, the Fisheries Act, the Inuvialuit Final Agreement, the Arctic Marine Conservation Policy, Northern Land-use Planning, the National Parks policy, a proposed whale management area, and the Canadian policy regarding the Alaska-Yukon marine boundary dispute. In general, most of these acts and policies are in place to protect and conserve the natural environment including the Beaufort Sea.

3.1.1 Ocean Dumping Control Act (ODCA)

The ODCA and role of RODAC were discussed earlier in Section 1.1. This Act regulates all disposal to the marine environment except from land-based discharges, and specifically includes inert wastes such as "ships, aircraft, platforms or other man-made structures... and, containers and scrap metal....". In addition to other wastes, "substances that, by reason of their bulk, would interfere with fishing...." and "materials which could have possible effects on other uses of the sea...", are scrutinized before an Ocean Dumping Permit can be issued.

3.1.2 The Arctic Waters Pollution Prevention Act (AWPPA)

The AWPPA applies to all waters north of the 60th parallel. The jurisdictional area of the Act extends 100 miles from the Canadian coast, except between Labrador and Greenland where an international demarcation line has been established, and in the Beaufort Sea where the Yukon/Alaska border has been extended seaward. This Act prohibits the deposit of any waste (defined as anything that impairs the usefulness of water) in these waters, except where that deposit has been permitted by regulation under proper authority. It also prohibits the loading of wastes in the Arctic for dumping in water beyond the geographical zone outlined above, except by permit.

3.1.3 The Navigable Waters Protection Act (NWPA)

The Navigable Waters Protection Act prohibits the building or placement of any structure in, upon, over, under, through or across a navigable water body without the approval of the Ministry of Transport. Approval granted by the Minister for work pursuant to the Act is only an authorization to interfere with the public's right of navigation in the area and during the period that the work plans have been approved. It is neither an approval for construction, nor an authorization with respect to any statute, regulation or by-law (federal, provincial or municipal), which may require some other form of authorization related to construction, land use, noise, weed control or pollution control. Section 20 of the NWPA also restricts ocean disposal within navigable waters to areas in excess of 20 fathoms (37 m).

3.1.4 The Fisheries Act

Section 33 of the Fisheries Act prohibits the deposit of any deleterious substance into waters frequented by fish, except when in the amounts and under the conditions stipulated by regulations made by the Governor in Council. A deleterious substance, for purposes of the Act, is anything that would degrade, alter, or form part of the process of degradation or alteration of the water quality, so as to render the receiving water deleterious to fish or the use of these fish by man.

Section 34 of the Fisheries Act provides authority to set regulations regarding the protection of fish habitat. For example, the obstruction of waterways used by migrating fish or the destruction of fish spawning, nursery or feeding areas would be regulated by the Fisheries Act, Section 34, which makes it an offence to carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat as specified in Section 31 of the Act (defined as any spawning grounds or nursery, rearing, food supply or migration areas on which fish depend, directly or indirectly, in order to carry on life processes).

3.1.5 The Inuvialuit Final Agreement

The Inuvialuit Settlement Region agreed upon in 1984 is illustrated in Figure 2 (Indian and Northern Affairs Canada, 1985). All of the Canadian Beaufort Sea is located within the boundary of this region. By the Agreement, the federal government retains the right to manage and control waters, waterways, beds of

Figure 2. Inuvialuit settlement region (Indian and Northern Affairs Canada, 1985).

rivers, lakes and water bodies, but agrees to consult with the Inuvialuit with respect to the exercising of these rights. This would include the selection of a common-user ocean dumpsite in the Beaufort Sea.

Any development that may have a negative impact on present or future wildlife harvesting within the Inuvialuit settlement region will be subject to a review process undertaken by an Environmental Impact Screening Committee. This committee consists of at least seven permanent members (three appointed from the government, of which one will represent each of the Territorial governments and one the federal government, three appointed from the Inuvialuit, and one or more individuals jointly appointed from any pertinent group). The Committee can recommend to government that a project proceed, not proceed or be modified. Where a proposed development may be subject to a governmental development or environmental impact review process, which the Committee believes will provide an adequate assessment of potential impacts, the Screening Committee may refer the development proposal to the government body responsible for that process.

An Environmental Impact Review Board, consisting of an additional seven members with the same representation as outlined above, has also been established. The role of this board is to review all projects referred to it, and on the basis of the evidence and information before it, to recommend whether or not the development should proceed. If the development should proceed, it then indicates the terms and conditions, including any mitigative and remedial measures. The Review Board may also recommend that the development be subject to further assessment and review and, if so, what data or information are required during this review.

3.1.6 National Parks Policy

Parks Canada has divided Canada into 39 terrestrial and 9 marine "natural regions", and a national park may eventually be established within each of these regions. The Beaufort Sea area includes portions of one marine and several terrestrial natural regions. Within each natural region, Parks Canada may identify "Natural Areas of Canadian Significance" (NACS) that are representative of the region in terms of both abiotic (landform, geology, etc.) and biotic components. "National Sites of Canadian Significance" (NSCS) are small areas within the region that contain unique, or rare, natural components.

The Yukon North Slope from the Alaskan boundary to the eastern shore of the Babbage River has been declared a National Park, and has been referred to as such in

the Inuvialiat Final Agreement. Within the park, provision has been allowed to authorize limited short-term development on a forty-acre site at Stokes Point. In addition, all of Herschel Island, with the exception of lands immediately adjacent to Pauline Cove, has been declared a Territorial Park and the historic resources adjacent to Pauline Cove are fully protected.

Parks Canada is currently considering the area near Nelson Head for park status, and is examining the Tuktoyaktuk Peninsula to Baillie Island (including Liverpool Bay) and western Kugmallit Bay (including the Pullen Island area) for designation as a marine area of Canadian significance in order to protect a group of pingos which are considered a unique type of landform. A submarine area 100 km north of Toker Point, known as the Kugmallit Pingo area, has been recommended as a natural site of Canadian significance. No ocean dumping would be permitted if any area were to be declared a National Park or a Canadian Landmark (D.B. Yurick, Parks Canada, pers. comm.).

3.1.7 Proposed Whale Management Area

A proposal has been put forward by the Department of Fisheries and Oceans to declare the areas around the numerous outlets of the Mackenzie River a white whale management area. In particular, that region of Mackenzie Bay from King Point to Pullen Island and extending into Niakunak (Shallow) Bay may be subject to various restrictions because of its apparent importance to white whales.

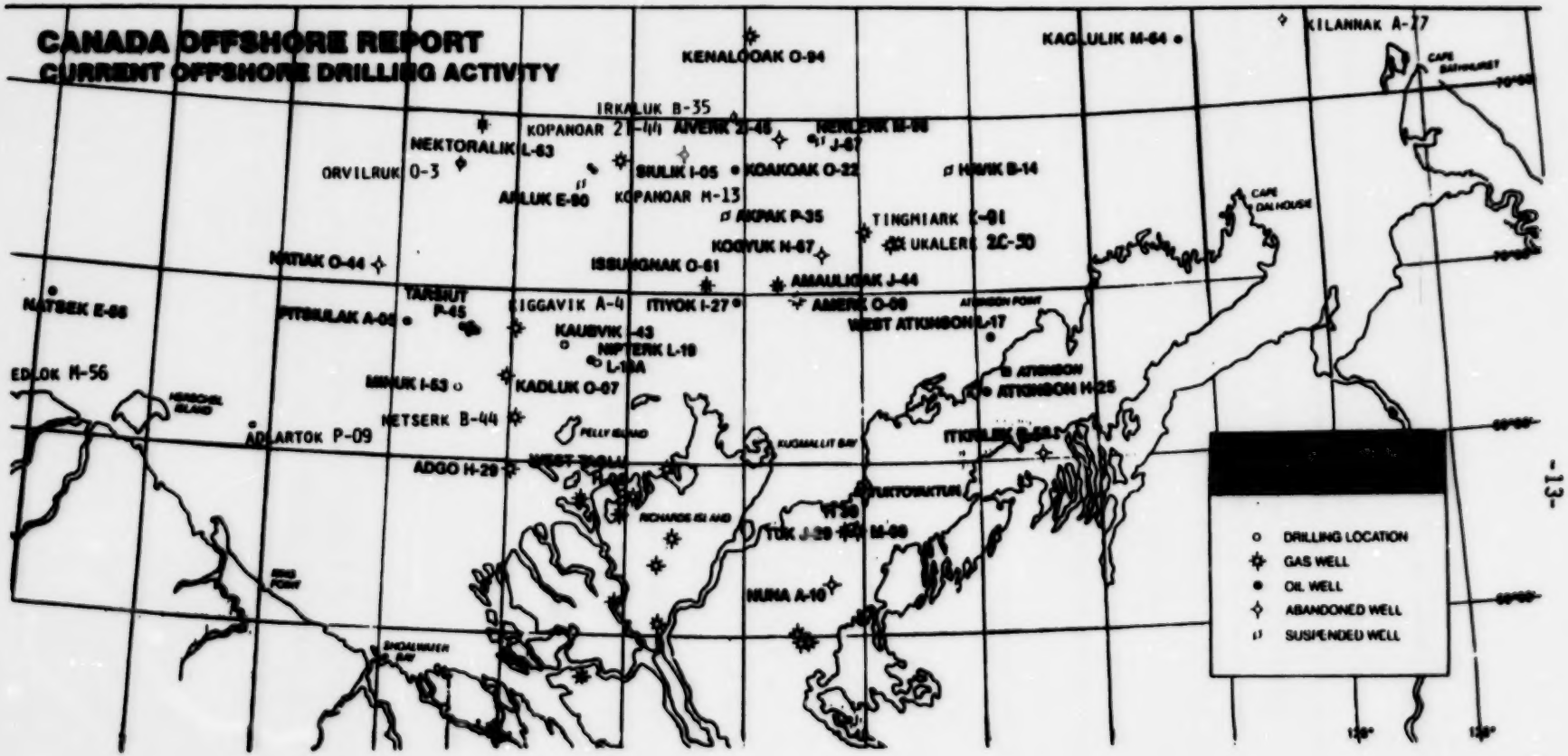

Figure 3. Current offshore drilling activity in the Canadian Beaufort Sea (Oilweek, 1985).

3.1.8 Canadian Policy Regarding the Alaska/Yukon Border Dispute

At present, the boundary separating Canadian from American Beaufort Sea waters is an extension of the land boundary between Alaska and the Yukon Territory (141°W). The U.S. government has proposed that the marine boundary follow a straight line from the present land border at 141°W to where that line intersects 70°N at 140.25°W and 71°N at 139.3°W. This line would be approximately 6° east of the present demarcation. The position of the Canadian government is to maintain the boundary as it is presently drawn. It is the policy of EP not to issue permits for ocean disposal in areas where national boundaries are in dispute.

3.2 Oil and Gas Development

3.2.1 Oil Leases and Drilling Sites

Locations of current oil and gas operations in the Beaufort Sea region are illustrated in Figure 3. Seismic data acquisition in the offshore Beaufort began in the early 1970's, with the first well being drilled in 1973 at a shallow water artificial island site called Immerk. Since this date, approximately 30 artificial islands or berms have been constructed in water up to 22 m deep. Drilling has also taken place from drillships operating in offshore waters (from 23 to 70 m deep) during the short open-water season from July through September. Approximately 30 wells have been drilled in this manner. In total, about 50 wells have been drilled in the offshore Beaufort to date.

3.2.2 Borrow Areas

The numerous artificial islands in the southern Beaufort Sea have been constructed with sand and gravel dredged from within the region. Estimates of the total quantity of borrow materials needed for all offshore facilities until the year 2000 range from approximately 500 to 700 million cubic metres (Dome et al., 1982b).

Based on these estimates, a maximum of about 50 to 70 km^2 of sea floor could be directly disturbed during this time period, assuming that dredging is limited to a depth of 10 m below the sea floor. Most dredging has occurred, and will continue to occur, during the open-water period. Locations of the most probable borrow areas in the southern Beaufort Sea are shown in Figure 4.

3.3 Shipping and Other Uses of the Sea

3.3.1 Marine Transport

Marine access to the Beaufort Sea is possible through two transportation corridors: a western route through Bering Strait and the Chukchi Sea, and an eastern route through the Northwest Passage (Parry Channel) and Baffin Bay. Sea ice prevents shipping by conventional vessels from about November to June, depending on annual variations in ice conditions. The western route through the Bering Sea is used for most Canadian Beaufort Sea operations. Three general groups of marine vessels use this route: those asociated with the offshore drilling fleet, those undertaking scientific surveys, and ships used for supplying Arctic communities (Dome et al. 1982b).

The intensity of vessel traffic, and the location of primary shipping corridors vary to some degree each year, depending on the specific locations and types of petroleum industry operations in the region. Most vessel movements occur between the two primary shorebases (Tuktoyaktuk, McKinley Bay) and offshore exploratory drilling or artificial island construction sites, as well as between various industrial sites in the offshore. Since 1981, there have also been vessel movements between Pauline Cove (Herschel Island) and the main industrial development zone north of the Mackenzie Delta and Tuktoyaktuk Peninsula. During the period 1980-1986, the entire industrial zone was located shoreward of the 100 m isobath (Richardson et al. 1985; Duval et al. 1986) and, therefore, vessel traffic associated with oil industry operations has largely been restricted to areas within this water depth. The design draft of vessels operating in this zone is less than 10 m (Dome Petroleum et al. 1982b).

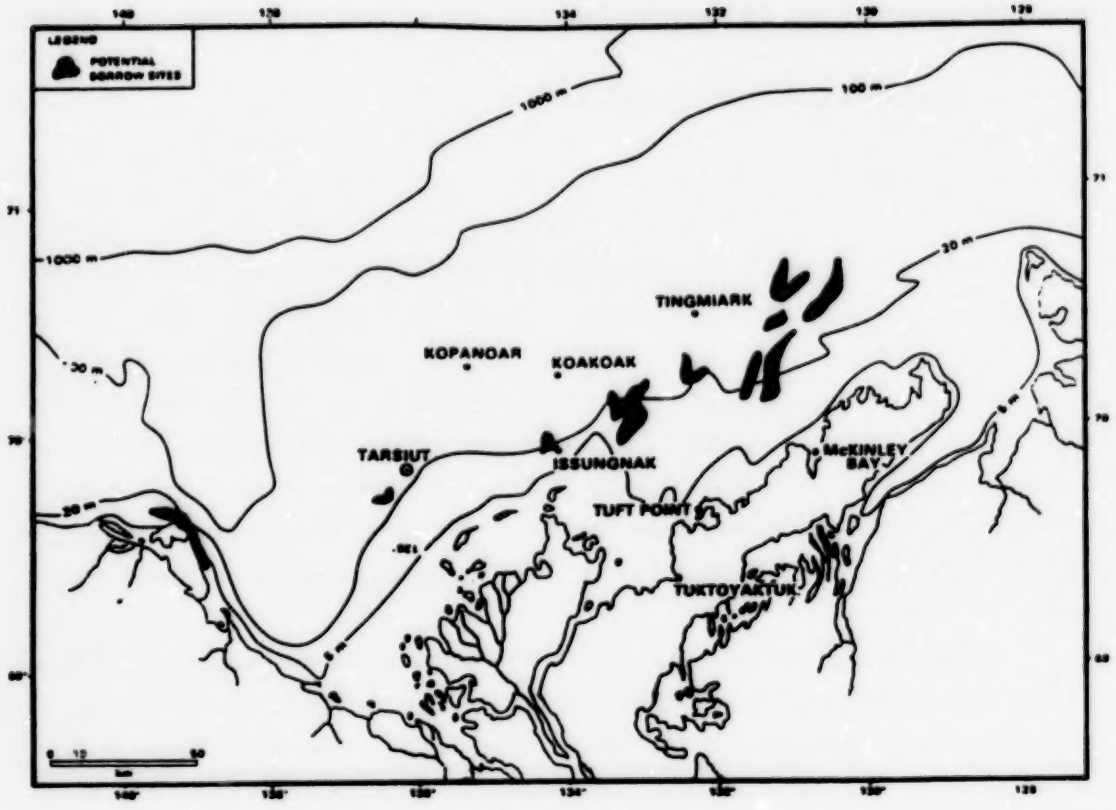

Figure 4. Known or potential borrow sites in the offshore Beaufort Sea. (Dome et al. 1982b).

The Mackenzie River is a vital transportation link between southern Canada and the communities and industrial sites along the Beaufort Sea coast and on the Mackenzie Delta. A major transport operation is undertaken on the river each year between May and early October. Supplies and heavy equipment are moved by road and rail to a terminal at Hay River, and are then barged to communities in the Delta and along the coast. Two companies handle freight on the Mackenzie River route. The largest is the Northern Transportation Company Ltd. (NTCL), which services the Delta, Banks Island, Victoria Island and points along the coast from Colville River in Alaska to Spence Bay in the east. NTCL is licensed to transport supplies to the communities, but is also a major carrier for oil companies operating in the north. At present, NTCL owns 169 barges, of which 165 operate on the Mackenzie River and Delta and/or in other parts of the western Arctic. The company also owns and operates 29 powered vessels in the same region (Capt. Waldmough, Northern Transportation Company Limited (NTCL) pers. comm.).

Arctic Transportation Ltd. (ATL) has a small operation on the Mackenzie River and a major operation offshore in the Beaufort Sea. It is not licensed to serve the northern communities, and all of its contracts are with the oil industry. ATL's offshore operations in the Beaufort region usually extend from mid-June to the end of October. These are based at Tuktoyaktuk, where ATL has constructed a new base with the largest dock facility in Tuktoyaktuk. In the past, ATL operated two seismic survey ships, three vessels for offshore supply services, eight tugs and twenty barges.

Transport Canada has public wharf facilities at Tuktoyaktuk, and NTCL also has wharves and facilities near this community. In addition, Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc. have dock and marine support bases along Tuktoyaktuk Harbour and in McKinley Bay.

3.3.2 Fish and Wildlife Harvesting

The harvest of fishery and wildlife resources is important to the cash economy of Beaufort coastal communities and provides social, cultural and nutritional benefits to the Inuit.

The communities involved in resource harvesting are Inuvik, Aklavik, Tuktoyaktuk, Sachs Harbour, Paulatuk and Holman Island. The first three of these harvest primarily fish and white whales for domestic use. The remaining three communities are involved in the harvest and export of seal skins, Arctic fox pelts and polar bear hides (Brakel, 1977). Residents of Inuvik, Aklavik and Tuktoyaktuk also hunt fox and polar bear and market their pelts and hides.

The major Beaufort Sea fish species harvested include Arctic char, Arctic and least cisco, inconnu, and Pacific herring (Brakel, 1977; Corkum and McCart, 1981). Few fish are taken in coastal Beaufort Sea waters, with most species being harvested from the Mackenzie Delta, small rivers and coastal lakes. Most fish are used domestically, and there are currently no major commercial fishing operations in the Canadian Beaufort Sea region. Fishing is primarily an open-water season activity, centred in the Delta and near Tuktoyaktuk, although some harvests occur along the Yukon coast and west of Tuktoyaktuk. Most of the fish taken in the Delta are anadromous or freshwater species, with broad and humpback whitefish comprising 50% of the catch. Sachs Harbour (on Banks Island) and Holman Island (Victoria Island) have small domestic fisheries directed at Arctic char and whitefish (Fraker et al. 1979).

White whales are harvested during their spring migration into the Mackenzie River estuary. Between 1972 and 1981, an average of 132.8 white whales were landed in the Beaufort Sea per year (Fraker and Fraker, 1982). The hunt has a cultural significance for the Inuit, and provides fresh meat, muktuk and oil for domestic use (Brakel, 1977). The white whale harvest involves about 100 families annually, and begins in late June and continues intensely for about three weeks. Kugmallit and Shallow (Niakunak) Bays are the primary sites of the hunt.

The harvest of ringed seals is particularly important to the communities of Sachs Harbour, Paulatuk and Holman Island. Bearded seals are also taken, but they represent only 2 to 4% of the total seal harvest (Usher, 1965). Although some seals are shot during the winter when they surface at their breathing holes in the landfast ice, most are taken during late spring break-up when they are hauled-out on the ice to moult (Kemp et al. 1977).

In summary, a variety of resources are harvested by the Inuit from coastal communities in the Beaufort Sea region, although with the exception of seals and white whales, hunting and fishing activities are confined to either freshwater or shallow, nearshore waters. For these resources, a disruption of harvest activities by ocean dumping or associated vessel traffic is therefore unlikely to occur. Similarly, the annual white whale harvest occurs in Kugmallit and Niakunak Bays and the industry avoids use of these areas at the time of the hunt (INAC and Environment Canada, 1984). Disruption of the seal harvest (primarily ringed seals) is also improbable because most of the hunt occurs outside the study area within Amundsen Gulf and takes place in late spring when ocean dumping is unlikely to be attempted because of ice conditions.

4.0 ENVIRONMENTAL EFFECTS OF OCEAN DISPOSAL OF INERT WASTES

The environmental effects of ocean disposal of solids have been the subject of numerous research and monitoring programs, particularly in relation to the discharge of dredge spoil (e.g., Wright, 1978; Levings, 1982; Kester et al. 1983; Nixon, 1984). Effects on biota and the physical environment are confined to the immediate vicinity of dumpsites and, in the case of bulky inert materials, include smothering or disturbance of biota in areas where wastes accumulate on the seafloor and short-term effects of increased turbidity and sediment re-distribution (Murden, 1984).

The potential effects of solid waste disposal in the Beaufort Sea were examined by Dome Petroleum et al. (1982b) and ESL (1982) as part of the Beaufort Sea-Mackenzie Delta Hydrocarbon Production Environmental Impact Statement. Both of these sources indicated that ocean disposal of inert solids would have localized impacts on the environment and biological resources, with the most serious effect being the smothering and loss of benthic organisms at dumpsites.

The working group participating in Phase I of this project deliberately over-estimated the quantity of inert wastes that could be dumped in the Beaufort Sea. The group concluded that a total of 3.75 million tonnes of material, dumped over a 75-year period, would provide a safety margin of ten times the actual quantity expected (Thomas, 1984). Assuming a bulk density of approximately 2 tonnes/cubic metre and accumulation of material at the dumpsite to a depth of 2m, this waste would cover about 1.0 km^2 of Beaufort Sea seabed. The area of the Beaufort Sea shelf is approximately 60,000 km^2 and, therefore, the total extent of seafloor potentially disturbed by ocean dumping would be relatively insignificant (i.e., < 0.002 percent). By comparison, a single artificial island occupies about 0.2 km^2 of seafloor, or one fifth of the area that is estimated could be disturbed by ocean dumping over 75 years.

4.1 Effects on Biota

Benthic organisms would be the biota most seriously affected by ocean dumping of bulky inert wastes, although effects would be very local. The organisms and habitats in the zone where wastes accumulate on the seafloor would likely be destroyed. Around the actual "impact" zone, there would be a zone of disturbance in which displaced sediment, resuspended by the falling wastes, would cause increased

turbidity and possibly some suffocation or clogging of the feeding apparatus of zoobenthic organisms, particularly epifaunal species. Any effects within this zone adjacent to the dumpsite, however, would likely be similar in type and magnitude to those caused by sediment re-working and suspension due to natural processes such as river discharge and ice scour in shallow areas. Effects at and adjacent to the dumpsite would be very local, and ocean dumping of inert wastes would not cause any regionally-significant impact.

Alterations in bottom contours, particle size distribution of exposed sediments, and food availability may alter rates of benthic recolonization, survival and reproduction, and may lead to changes in benthic species diversity and population dynamics (Dome et al. 1982b). Although one type of benthic habitat would be lost within a localized area by disposal of bulky inert wastes in the Beaufort Sea, these wastes themselves would create a new, hard substrate for benthic colonization. Studies completed in relation to dredging projects in this region have shown that recolonization by populations of species previously in the area and colonization by new species adapted to hard substrates would be relatively rapid, with benthic biomass recovering to pre-dumping levels within 2 to 3 years (Envirocon Ltd. 1977; Olmsted, 1977; Beak Consultants, 1981; and Thomas et al. 1982). Recovery of benthic communities in areas of bulky inert waste disposal would likely require longer periods than those estimated for dredging projects due to the persistence of accumulated solids on the seafloor and permanent, localized loss of benthic habitat in some areas. On the other hand, the presence of bulky wastes on the seafloor would create new habitat for some populations. It is well documented that the diversity and biomass of benthic fauna (and associated fish populations) are often enhanced in the vicinity of scrap metal ocean dumpsites due to (1) increased habitat diversity, (2) availability of shelter for mobile fauna, and (3) the tendency for individuals of some species to be attracted to debris accumulations on the seafloor (e.g., Wickham et al. 1973; Wickham and Russell, 1974; Russell, 1975; Gallaway et al. 1979; Chin et al. 1979 and numerous others). Both positive and negative impacts of solid waste disposal, however, would be local and insignificant in comparison with the total benthic habitat and biomass of fauna on the Beaufort Shelf.

Repetitive use of a dumpsite may prevent or hamper re-establishment of benthic populations due to incremental physical damage to or suffocation of fauna. This can be circumvented to some degree by ensuring that freshly dumped material is not placed on top of material previously dumped, although that practice would also increase the overall area of impact. Timing restrictions on dumpsite use to avoid seasons of benthic recruitment (e.g., larval settlement) would limit the

adverse effects of solid waste disposal and hasten rates of recovery of populations in the vicinity of dumpsites. Uplifting and re-distribution of surficial sediments could also interfere with larval settlement and subsequent survival, thereby increasing the time necessary for benthic biomass to return to pre-dumping levels.

The impact of dumped wastes on the seafloor would cause some resuspension of sediments, thereby increasing water turbidity in the vicinity of the dumpsite. Such increases in water turbidity could cause short-term and local decreases in the rates of primary productivity by phytoplankton if light penetration was reduced in the upper portion of the water column. In deeper, offshore waters, this would be unlikely to occur because the vertical density stratification of the water column would prevent or limit transport of turbid water to the surface. In most shallow areas, any increases in water turbidity resulting from ocean dumping would be indistinguishable from natural suspended sediment levels associated with the Mackenzie River plume. Consequently, any effects of ocean disposal of solid wastes on phytoplankton communities would be insignificant.

Depending on the location, frequency and scale of the ocean dumping activity, some fish spawning, rearing or feeding habitats may be disrupted or altered. The risk of adverse effects on fish and their habitat would be greatest in shallow coastal waters that are important for several anadromous species (e.g., broad whitefish, least and arctic ciscoes) and Pacific herring harvested in domestic fisheries. The loss of certain benthic organisms could also have an indirect effect on some species of fish, birds and marine mammals. The small numbers of prey organisms lost through dumping, however, would have only a local effect on predator species, and is not a significant area of concern from a regional perspective given the widespread distribution of prey populations.

The combined disturbances associated with the dumping of bulky inert wastes in the Beaufort Sea, such as underwater noise, vessel movements and re-suspension of sediments, might cause avoidance responses in some marine-associated birds and marine mammals, particularly white and bowhead whales during the actual dumping operations. Wildlife observations during dredging programs conducted in this region suggest that disturbance of seals would be negligible (Ward, 1981). The removal of benthic fauna may cause a local reduction in food sources for certain bird species and bearded seals, which are known to feed on benthic infauna and epifauna (Stirling et al. 1977; Wursig et al. 1981). Any losses of benthic fauna would be very local, however, and their effect on members of higher trophic levels would be negligible. The same conclusion can be reached regarding the overall impact of any increase in

turbidity on the feeding of diving birds, ringed seals, white whales and bowhead whales. Prey detectability may be reduced if sediments are resuspended, but any effects of decreased visibility of prey would be very local and temporary.

In summary, the impacts of ocean dumping of inert wastes on marine biota would be very local, short-lived, and of negligible significance in terms of the entire Beaufort Sea ecosystem. The possibility exists, however, that biological productivity will be increased within the dumping area due to the increased availability of hard substrate for larval settlement and the corresponding increase in food organisms and shelter for fish.

4.2 Effects on the Physical Environment

4.2.1 Water Quality

The only effect of ocean disposal of bulky inert wastes on water quality would be a local increase in turbidity resulting from the resuspension of sediments when the wastes contact the seafloor. These turbidity values are expected to be within the range attributable to natural processes, including Mackenzie River discharge, storm surges, ice scouring, and the resuspension of shallow water sediments by storm wave action (Thomas, 1984).

The corrosion rate of steel in sea water depends on the type of steel and whether or not it has been painted or coated. 1016 carbon steel (uncoated) corrodes at a rate of 0.102 to 0.127 mm per year (Uhlig, 1963; Newnes, 1979). Steel composed of 0.2% carbon and 0.02% copper exhibits a weight loss of 27.0 mg per square decimetre of surface per day in sea water (Uhlig, 1963). Even stainless steels would tend to pit and fatigue with time. These processes occur very slowly and, therefore, the rate of trace metal introduction to the water column due to steel corrosion would be negligible.

Overall, the changes in water quality associated with ocean dumping of inert solid wastes would be well within the range expected to occur naturally in the Beaufort Sea. As a result, the impact of this activity on water quality is expected to be insignificant.

4.2.2 Oceanographic Parameters and Bottom Sediments

The ocean disposal of bulky wastes in shallow water (less than 40 m) would affect seabed contours and cause alterations to wave or current patterns and

sediment particle size distributions. Such effects would be indistinguishable from those attributable to natural phenomena, particularly ice scour and storm surges, which continually alter seabed contours on an extensive scale. Dumping in deeper waters would result in a minimal decrease in the water depth relative to total depth, particularly if successive dumping was off-set. Therefore, the effects of this activity on currents and wave patterns in the offshore would not be significant.

The resuspension of fine sediments on the seafloor due to dumping could alter the sediment particle size distribution of the seabed at or downstream of the dumpsite. This phenomenon has been observed downstream of artificial island sites (Envirocon, 1977; Beak Consultants Ltd., 1978). These effects would be very local, and they would generally be insignificant in comparison to the effects of natural phenomena such as sediment deposition by the Mackenzie River, ice scouring, erosion and slumping.

Currents

Currents throughout the study area are most affected by the wind field and the discharge of the Mackenzie River. Currents are also affected by factors such as tides, water column structure, offshore currents (e.g., the Beaufort Gyre) and bottom topography. Although the quality and reliability of the data pertinent to this study vary widely, conclusions can be drawn which give a general description of the current field and its behaviour over the broad expanse of the area of interest.

Subsurface currents are predominantly wind-driven, the response varying markedly with location and depth. The most prominent feature of the subsurface currents is their extreme directional variability, which appears to be in response to variations in the wind field. Data, taken mainly offshore, show net near-bottom currents persistently move toward the northeast on the shelf at 4 cm/s or less. Fissel and Birch (1984) found offshore near-bottom currents in the summer to have maximum speeds ranging from 16 to 29 cm/s; closer inshore maximum speeds ranged from 40 to 50 cm/s. Current speeds are significantly lower in winter because of the decoupling of winds and currents caused by ice cover.

The role of topography in determining current directions is not clearly understood, but it is observed that currents on the shelf generally follow the isobaths aligned with the coast. Consequently, the mean flow on the continental shelf adjoining the Tuyktoyaktuk Peninsula is from southwest to northeast. In the gently

sloping Kugmallit Trough off Kugmallit Bay, currents are seen flowing north-south across the shelf. Currents in the region of the Mackenzie Canyon generally follow the isobaths, with some intensification occurring along steep slopes.

It is improbable that dumping in deeper waters would significantly alter currents or circulation, as these processes are primarily influenced by the wind field and the river discharge. Local effects on currents may occur through the alteration of bottom topography. It appears that these effects could be limited by the orientation of the boundaries on the dumping ground parallel to existing isobaths.

Current models of wave climate in the Beaufort Sea do not indicate an influence of topography or water depth in depths greater than 30 m (Baird and Hall, 1980; Readshaw, 1983). Dumping in water more than 30 m deep should, therefore, not have significant effects on wave climate.

Of greater concern is the possibility of bottom currents or wave-induced disturbance transporting dumped materials along the bottom. This concern has been examined by de Lange Boom and Wainwright (1985) with respect to potential subsea pipeline routes.

The maximum near-bottom current-speeds encountered in the offshore areas (approx. 30 cm/s) would likely be capable of transporting materials along the bottom if they present a large surface area to the current relative to their weight. Before transport was initiated, the force of bottom suction would have to be overcome, which in a silt-clay bottom is likely to be high. Materials which might commonly be expected to be moved in a strong wind, such as an empty oil barrel on its side, would potentially be transported by currents. It is recommended that such wastes be crushed prior to dumping.

Ice

For eight to nine months each year (October through July) ice of varying thickness covers most of the Beaufort Sea. An ice free corridor develops along the coast during the summer months. The ice cover can be divided into three regimes: 1) the landfast ice, 2) the seasonal (transition zone) ice and 3) the polar pack ice. The maximum horizontal extent of the landfast ice in the southern Beaufort Sea generally occurs between mid-November and early May. First year ice thickness reaches a maximum of 1.5 to 2 m by late April.

The start of breakup varies from year to year depending upon the wind, temperature and the volume of the Mackenzie River discharge. Typically, breakup

begins in the seasonal ice zone with the development of flaw leads in mid-May or early June as a result of an increase in river flow. The presence of open water allows increased insolation as well as increased fetch over which the winds act, allowing wind-generated wave action to play a larger role in the deterioration and removal of the ice.

In Mackenzie and Kugmallit Bays, flooding over the bottom-fast ice usually occurs in early May with the beginning of the freshet. Melt lagoons form and expand by melting the ice at the ice-water interface. Eventually, especially offshore, insolation becomes the dominant source of energy in melting the ice (Fissel and Birch, 1984). The landfast ice generally remains firmly in place until the sections north of Shallow Bay and Kugmallit Bay are eroded away. Following the breakup of these sections the remaining landfast ice deteriorates quickly and drifts away.

The rate at which breakup occurs depends in part upon the wind. Dispersal of the ice offshore is enhanced by easterly winds which can result in up to 200 km of open water between the shore and the edge of the pack ice. Complete removal of the landfast ice generally occurs by mid-July. Studies at Tingmiark show that for the period 1953 to 1980, the open-water season ranged from 0 to 160 days (Dome Petroleum Limited et al. 1982).

If the winds are light or predominantly from the west to northwest in the spring or summer, the ice remains near the shore or is forced shoreward. Periodically the ice will remain near shore for most of the open-water season (Figure 5). In 1955, 1964, 1967, and 1974, onshore winds pushed the polar pack ice into coastal water causing multi-year floes to move into water depths as shallow as 5 metres.

From late July to October the southern Beaufort Sea is generally ice free. Ice invasions into the nearshore zone due to onshore movements of the pack-ice edge frequently occur in August and September with clearing resuming in September (Fissel and Birch, 1984). Maximum open water occurs during the period from September to the beginning of formation of ice, usually in early October. The Yukon coast freezeup starts as much as 2 to 4 weeks earlier.

As can be seen easily from Figure 5, access to a deep water dumpsite may be impractical during a "poor" ice year.

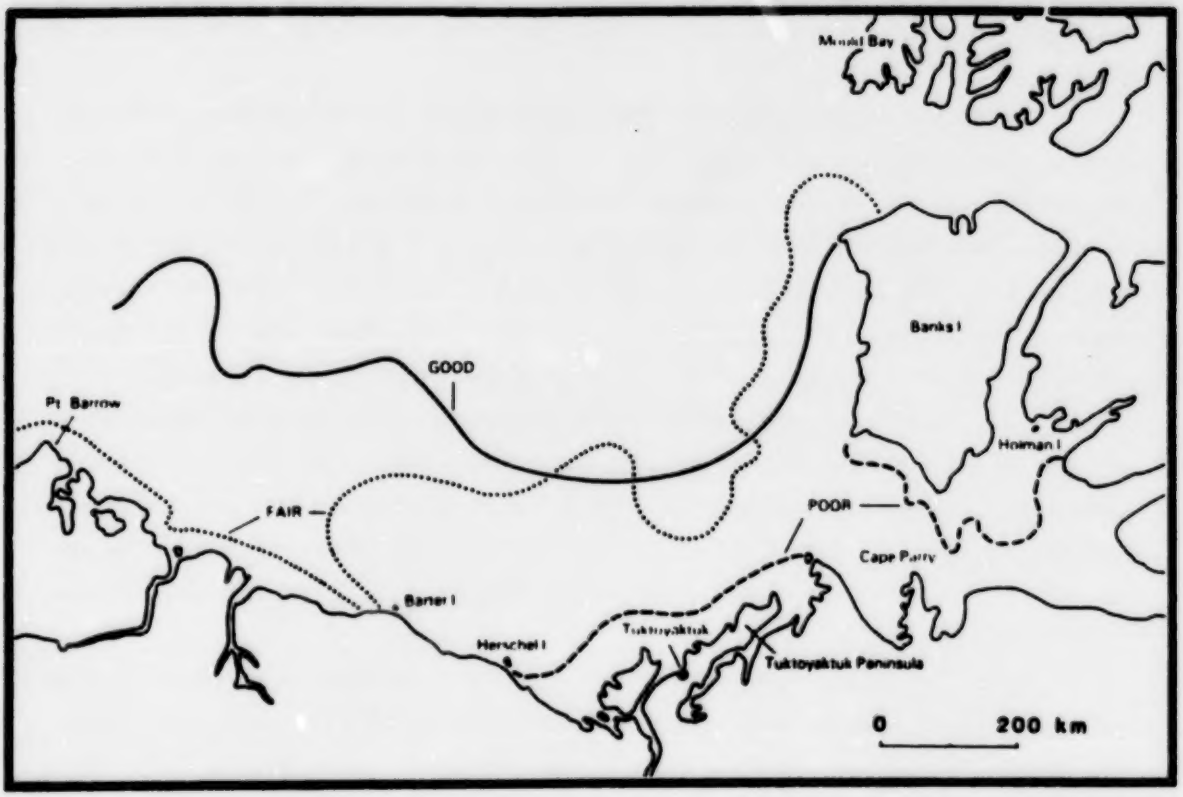

Figure 5. **Median position of the ice edge for late August in good, fair, and poor years: 1961 to 1972.** (Source: Milne and Herlinveaux, 1977).

5.0 METHODS AND COSTS OF OCEAN DISPOSAL

5.1 Alternative Methods

There are two general approaches to the ocean disposal of inert wastes in the Beaufort Sea. These are:

1. placement of wastes on the ice sheet using truck transport during winter; and

2. direct release of materials to the sea from barges or oilfield supply vessels during the open-water season.

Placement of wastes on the ice would be very expensive and, unless confined to the nearshore zone (< 20 m), would probably be impossible due to the presence of ice ridges offshore which could not be traversed by trucks. If this approach was even feasible, placement on the ice would likely lead to distribution of wastes over a wide area during spring break-up, when ice floes are transported long distances by surface currents and winds. On the other hand, relatively accurate placement of wastes on the sea floor is possible from a barge or ship during the open-water season and would be much more economical.

In terms of containment of wastes within a selected ocean disposal area, dumping from a vessel during the open-water season would be the preferred approach. Off-set dumping may eliminate concerns regarding the possible loss of colonizing benthic populations by repeated disturbance and the potential for accumulation of a large pile of debris by dumping at a single site over a period of months or years, thereby reducing the water depth and creating a hazard to navigation.

5.2 Costs

Most of the wastes to be disposed of by ocean dumping are presently stored at various locations in or near Tuktoyaktuk, N.W.T. (see Table 1B) or on the Yukon coast. Therefore, Tuktoyaktuk and King Point have been used as the departure sites for haulage distance calculations. For the cost estimates, it was further assumed that a straight-line route from Tuktoyaktuk seaward for 50 km would be necessary, followed by 50 km voyage segments in one direction or another to possible disposal

areas. In the case of King Point, only 50-km voyage segments from the shoreline were employed for the cost analysis.

As the wastes indicated in Table 1A and B are bulky, the best mode of transport (assuming open-water season disposal) would be by barge or oilfield supply vessel. Loads of 50 to 500 tonnes could be handled by a supply vessel, while larger loads should be hauled by barge. An on-board crane or other dumping mechanism would be necessary on either type of vessel. It is assumed that one day would be required to load and unload the vessel and that three hours would be required to travel each 50-km trip segment.

Given the foregoing assumptions, the minimum base cost for a single load, using a barge or tug, is estimated to be $21,000, plus $7,000 for each 50-km round trip voyage component (J. Wainwright, Arctic Transportation Limited, pers. comm.).

6.0 APPLICATION OF CONSTRAINT CRITERIA TO OCEAN DISPOSAL AREA SELECTION

6.1 Constraint Criteria

6.1.1 Biological Constraints

In general, the biological constraints to ocean dumping of bulky inert wastes would be minimal due to the very small area that is expected to be affected by this activity and the non-toxic nature of the material. The effects of ocean dumping on some populations and communities would be greatest if waste disposal areas were located in nearshore environments (<20 m) of the Beaufort Sea, although the overall degree of impact would still be negligible in terms of regional biological resources. Nevertheless, certain biological factors should be considered in the selection of ocean disposal areas to ensure that dumping of bulky, inert wastes has minimal impact.

(a) Benthic Communities

As indicated earlier, benthic infauna and epifauna are the biological resources most directly and visibly affected by ocean dumping. The disposal of scrap metal and other solids will result in immediate losses of fauna in areas on the seafloor where these materials accumulate, as well as possible changes in faunal diversity and biomass in adjacent areas due to redistribution of surficial sediments. The new hard substrate, however, may also provide a surface for colonization by epifaunal species not found in adjacent soft-bottom areas, thereby increasing the overall faunal diversity at the dumpsite.

There are substantial regional differences in the diversity and abundance of benthic fauna throughout the Beaufort Sea. From the perspective of limiting the impact of ocean dumping on benthic fauna per se, disposal sites should be located in shallow nearshore areas where the diversity and biomass of benthic fauna is lowest due to seasonal ice scour and freshwater input from the Mackenzie River (Wacasey, 1975). In the "marine" zone (Wascasey, 1975) located farther offshore (30 -200 m), disturbance of a given area of seafloor is likely to affect greater numbers and a more diverse assemblage of fauna, particularly in the western portion of the Canadian Beaufort Sea. The indirect or trophic implications of loss of benthic fauna are, however, considered a greater area of potential concern in the nearshore

because of the importance of coastal areas for anadromous species of fish and some waterfowl (e.g., LGL and ESL, 1982; INAC and Environment Canada, 1984, 1985). For this reason, an offshore (> 50 m) disposal area would be preferable, despite the probable greater impact on benthic organisms per unit area of seafloor affected by dumping.

(b) Fish Populations

Ocean dumping has its primary effects on fish populations indirectly through alteration of benthic habitat and possible local changes in prey availability. An offshore ocean disposal area is considered preferable for several reasons. The fish species of greatest importance in local domestic fisheries (whitefish, cisco, char, herring) are most commonly found in shallow (< 10 m) coastal waters (Dome et al. 1982a; LGL and ESL, 1982). These species are unlikely to be affected either directly or indirectly by any ocean dumping activities in the offshore Beaufort. On the other hand, nearshore ocean disposal of solid wastes could directly affect anadromous species by altering migration patterns or by causing their temporary attraction to areas where debris has accumulated on the seafloor. Indirect effects of ocean disposal on anadromous species could also occur from the local loss of benthic prey organisms (epifauna) for fish that feed in coastal waters. Depending on the location of dumpsites, dumping could also affect the spawning habitats of Pacific herring and other non-harvested marine species (capelin, snailfish, fourhorn sculpin).

In the offshore Beaufort, only marine fish species would be affected by ocean disposal of solid wastes. Direct losses of slow-moving demersal fish could occur during the actual dumping operations, although any mortality would not be significant in relation to regional populations. Some local loss of benthic habitat and prey organisms would also occur, but eventually the site(s) of debris accumulation on the seafloor would almost certainly attract some species of pelagic and demersal fish due to the "reef effect" (e.g., Gallaway et al. 1979; Wickham et al. 1973), where increased shelter and availability of prey (particularly epibenthic invertebrates) result in congregation of fish. Therefore, it is concluded that the impact of bulky inert waste disposal on fish populations in the Beaufort Sea would be minimized by selecting one or more offshore ocean disposal areas.

(c) Birds

Bird populations could be disturbed by vessel traffic and the human presence associated with ocean dumping operations, although only a few species such as snow geese are very sensitive to disturbance and then only at certain critical times of the year (Dome et al. 1982b; ESL 1982). Diving ducks may feed on benthic invertebrates in shallow coastal waters and, therefore, could be affected indirectly by any localized decreases in the availability of prey. Both direct and indirect impacts of ocean dumping on birds would be very site-specific and not significant to regional populations. Nevertheless, because the major concentration areas for birds (e.g., staging and nesting habitats) are in coastal environments (particularly sheltered bays), selection of an offshore area for disposal of solid wastes would minimize or eliminate any interaction with large congregations of waterfowl or other birds.

(d) Marine Mammals

The most common marine mammals found in the Beaufort region are ringed and bearded seals, bowhead and white (beluga) whales, polar bears and Arctic fox. The latter two species are unlikely to be found in areas where ocean dumping would be considered during the open water season and, therefore, are not discussed further in this report. On the other hand, whales could occur in areas selected for open water disposal, whereas seals are present in the region throughout the year.

Both ringed and bearded seals could be temporarily disturbed by ship movements and other activities associated with ocean dumping, whereas indirect effects on bearded seals could result from local losses of their benthic prey organisms at a shallow dumpsite. Food-related effects of ocean dumping on ringed seals are unlikely as this species feeds mainly on pelagic organisms such as amphipods and Arctic cod (Lowry et al. 1980). Seals generally inhabit areas of the Beaufort shallower than 50 m (Renaud and Davis, 1981; Stirling et al. 1981) and, therefore, any direct or indirect impact of ocean dumping on these species would be limited by selecting a dumpsite(s) beyond the 50 m isobath.

The distribution of bowhead and white whales in the Beaufort Sea varies throughout the open water season and among years. Individuals of both species can be found in offshore or nearshore areas depending on the ice regime, oceanographic conditions and month during the open water season. During late July and August, the

largest numbers of white whales typically occur within Niakunak (Shallow), Kugmallit and East Mackenzie Bays in the Mackenzie River estuary (Fraker and Fraker 1981; Norton and Harwood, 1985). The distribution of bowheads tends to be more variable, although the largest densities of bowhead whales have occurred along the Yukon coast during the last few years (Harwood and Ford, 1983; Harwood and Borstad, 1985; Duval et al. 1986). Consequently, the risk of interfering with the migration and feeding of whales in the region would be minimized by selection of an offshore area for disposal of inert solid wastes. Recent behavioural studies conducted in the region (Richardson, 1985) suggest that the impacts of ocean dumping on whales would likely be short-term avoidance responses to vessels at, or enroute to, the dumping area. It is expected that any responses would be temporary, involve only a few individuals in either population, and have no implications to the survival or productivity of any individual animals. The presence of bulky wastes on the seafloor is also unlikely to interfere with whale movements or feeding activities because these species have primarily pelagic habitats and feed mainly on pelagic rather than benthic invertebrates (bowheads) and fish (white whales).

(e) Conclusion

On the basis of available information regarding the distribution, abundance and life history characteristics of biological resources of the Beaufort Sea, as well as the known and anticipated effects of ocean dumping on these populations or communities, it is concluded that the overall impact of ocean dumping on the biotic environment would be minimized by selection of an ocean disposal area in offshore waters greater than 50 m and preferably 100 m deep.

6.1.2 Climatological and Oceanographic Constraints

The nearshore regions of the Beaufort Sea are characterized by variable and often harsh physical environmental conditions, whereas the offshore regions are comparatively stable. The nearshore zone, landward of the 20 m isobath, is exposed to the forces of winds, waves, storm surges, long-shore currents, tidal action, river discharge and variable ice conditions. These conditions can resuspend sediments and cause their redistribution over a wide area of nearshore habitat. On the other hand, the physical environment in offshore areas is considerably more stable below a water depth of 10-15 m. Currents are the primary oceanographic factor that varies in such

areas, but differences are expected to be small compared with those in the upper portion of the water column in offshore areas and in nearshore environments. Because of this greater stability in deeper offshore areas, bulky wastes deposited on the ocean floor are less likely to be transported to adjacent areas. It is concluded, therefore, that water depths shallower than 20 m would be an oceanographic constraint in ocean disposal area selection. (Additional information on currents is provided in Section 4.2.2).

6.1.3 Geological Constraints

There should be no secondary movement of deposited materials at an ideal ocean dumpsite. For this to be the case, there should be no significant spatial or temporal changes in the predominant current regime which could lead to variable sediment erosion, deposition or dispersal patterns, and no significant alterations to structural or other geological equilibria. Very strong bottom currents, ice scouring or mass sediment movements could cause redistribution of wastes once they are deposited on the seafloor. As indicated earlier, the potential for this to occur is greater in nearshore environments shallower than 20 m because of the more severe oceanographic conditions in this region. Ice scouring is of prime concern in waters shallower than 50 m because it can redistribute materials and drag wastes along the ocean floor. For this reason, shallow (< 50 m) waters are considered an important constraint in the selection of ocean disposal areas.

Some parts of the seafloor in the Beaufort Sea are susceptible to sediment slumping, particularly along the Mackenzie Canyon and along the edge of the continental shelf. The area affected by ocean dumping is, however, very small in relation to the total seafloor area and the quantity of solid wastes to be disposed of is not large. Therefore, it is considered highly unlikely that increased loads would induce en masse sediment slumping. Any slumping that might occur in areas of waste deposition would largely be indistinguishable from natural slumps in this region. Although the potential for sediment instability is not considered a major constraint in selection of ocean disposal areas, areas that are known to be susceptible to slumping should be avoided where possible. This should be evaluated during any surveys of preferred dumpsite locations, in conjunction with collection of other baseline oceanographic and biological data.

Similarly, changes in normal current and sediment dispersal regimes resulting from alteration of bottom contours are not expected to be a significant concern or constraint. Ice scouring causes repeated changes in bottom contours in nearshore

environments of the Beaufort Sea, and any incremental changes resulting from waste deposition would be local and of limited concern. Sub-surface currents in offshore areas are even weaker (Aagaard, 1978, 1979; Aagaard and Haugen, 1977), and changes in bottom contours due to ocean dumping are unlikely to cause significant changes to the velocity or direction of currents in these deeper environments.

The introduction of large quantities of scrap metal or other bulky solids could have an effect on other geological equilibria such as subsea permafrost or seismicity. Increased loading on permafrost sediments may induce changes in ice-bonding degradation or aggradation, or cause increased seismicity. Although there is no evidence to suggest that such phenomena have occurred in this region, it is considered desirable to characterize potential dumpsites in terms of these two geological parameters. It is unlikely, however, to be a constraint in ocean disposal area selection.

6.1.4 Legislative and Policy Constraints

As indicated in Section 3.1, a number of government policies and regulations have an influence on the selection of an ocean disposal area. Most of these requirements are designed to protect and conserve the environment in its present state, or to prevent any alteration of certain significant areas. These policies and relevant government legislation must be addressed during the selection of an ocean disposal area.

In general, the areas most affected by government regulations and policies are those landward of the 20 m isobath. An exception is the area containing pingo-like features north of Toker Point. Most government concerns can be addressed by selection of an ocean disposal area in a region other than the Kugmallit pingo area where water depths exceed 20 m. Dumpsites could be located on the flat area between subsea pingos such that the dumped material is not depth-limiting. Therefore, shallow water depths and the Kugmallit pingo area are considered existing government constraints relevant to the selection of ocean disposal areas.

6.1.5 Oil and Gas Industry Constraints

The recent activities of the oil and gas industry in the Beaufort Sea were summarized in Section 3.2. Most of the exploratory wells have been drilled landward of the 50 m isobath, and most vessel traffic associated with industry operations also

occurs in this relatively shallow region. Future well sites could, however, be located in water depths up to 500 m, as oil and gas lease areas extend further offshore . As a result, water depth is not presently considered a constraint to future activities of the industry, providing deeper portions of the Beaufort Sea remain accessible and relatively free of ice during the drilling season.

On the other hand, the use of potential borrow sites as areas of ocean disposal is considered an important constraint by the oil and gas industry. The presence of scrap metal and other bulky wastes could conflict with future use of such areas as sand and gravel sources (E. Pessah, pers. comm.). Therefore, it is concluded that the presence of a known or probable borrow site is a constraint in selection of an ocean disposal area.

6.1.6 Constraints Related to Shipping and Other Uses of the Beaufort Sea

As indicated in Section 3.3.1, most marine transportation activities and corridors in the Beaufort Sea occur landward of the 100 m isobath. Navigable waters shallower than 37 m (20 fathoms) would be excluded as ocean disposal areas by virtue of restrictions contained in Section 20 of the Navigable Waters Protection Act. Although dumpsites could be located in water depths greater than 37 m, it would be desirable to avoid predominant transportation corridors in deeper areas if there is a potential for conflicts between ship movements and disposal activities per se.

The harvest of fish and wildlife resources in the Beaufort Sea is primarily restricted to coastal and nearshore habitats. If selection of ocean disposal sites in such shallow areas is contemplated (and is not in violation of the Navigable Waters Protection Act), then the timing of dumping activities and associated vessel traffic should be scheduled to avoid conflicts with any resource harvesting activities.

6.1.7 Summary of Primary Constraint Criteria

Based on the foregoing, it is concluded that there are five primary constraints in the selection of a suitable ocean disposal area for bulky inert wastes in the Beaufort Sea. These are:

1. shallow water depths (i.e., less than 50 - 100 m);
2. the Kugmallit pingo area;
3. the presence of borrow areas;
4. areas with unusually strong currents; and
5. areas which are inaccessible due to ice conditions.

6.1.7.1 Shallow Water Depths

Shallow water depths are a constraint for several reasons. Coastal habitats support important anadromous fish, marine mammal and bird populations at certain times of the year, and are also the primary areas where these resources are harvested. They are characterized by a harsh and variable physical environment as a result of ice scour, currents, river discharge and storm surges. These conditions would tend to cause displacement of some wastes disposed of in shallow areas. Much of the Beaufort Sea coastline has been designated as having a special significance by Parks Canada, whereas the oil and gas industry has centered most of its exploration and support activities in areas with water depths shallower than 100 m. Considerable marine transportation activities occur within this zone, and navigable waters less than 37 m would be excluded as ocean disposal areas by virtue of existing government legislation (Navigable Waters Protection Act).

Despite the constraints associated with the selection of ocean disposal areas in shallow parts of the Beaufort Sea, two other factors have to be considered in the evaluation of areas located farther offshore. These are: (1) the cost of transporting wastes a considerable distance from present storage areas, and (2) the potential that the area cannot be accessed because of the offshore ice regime (i.e., percent cover) and location of the permanent polar pack.

6.1.7.2 Pingo-Like Features

Parks Canada has indicated that the Kugmallit subsea pingo area could be considered a unique landform and, therefore, should be designated as a "Natural Area of Canadian Significance". Dumping should not therefore be approved in that area.

6.1.7.3 Borrow Areas

The oil and gas industry is opposed to ocean disposal of solid wastes in known or expected borrow areas because this would preclude their use as sources of granular materials for construction projects.

6.1.7.4 Areas with Unusually Strong Currents

Areas with unusually strong currents have not been identified and the recorded near-bottom current velocities in the Beaufort Sea would not be sufficient to displace bulky inert wastes. During extreme events the currents might be of sufficient velocity to roll empty barrels and if barrels are to be dumped they should be crushed to ensure that this does not occur.

6.1.7.5 Areas Inaccessible Due to Ice

Areas which are inaccessible in the summer due to the presence of polar pack ice vary from year to year depending on temperatures and wind conditions. Markham (1981) presents a series of charts which suggest that, in areas north of the Mackenzie Delta, accessibility to a site north of approximately 71°N might not be sufficiently reliable, while in the vicinity of Herschel Island reliability of access diminishes north of approximately 70°N.

6.2 Analysis of Non-Economic Constraints

The analysis of non-economic constraints associated with selection of an ocean disposal area assumed that the preceding five constraints had equivalent importance or "weight". The study area was divided into 41 blocks (Figure 6). Each block was 6100 km^2 (55 km x 111 m) and was assigned a designation as either "Unacceptable (U)", "Potentially Acceptable (P)" or "Acceptable (A)". A block was considered "Unacceptable" if all or most of the area was less than 50 m deep (e.g., Block 3) or contained a borrow site (e.g., Block 13). The results of this analysis and the rationale for the designation of each block are provided in Appendix 1. As evident from the rationale presented in this appendix, relatively high biological sensitivity, a potential for ice scouring, and the conflicting use of an area for oil and gas exploration, marine transportation or resource harvest activities were the

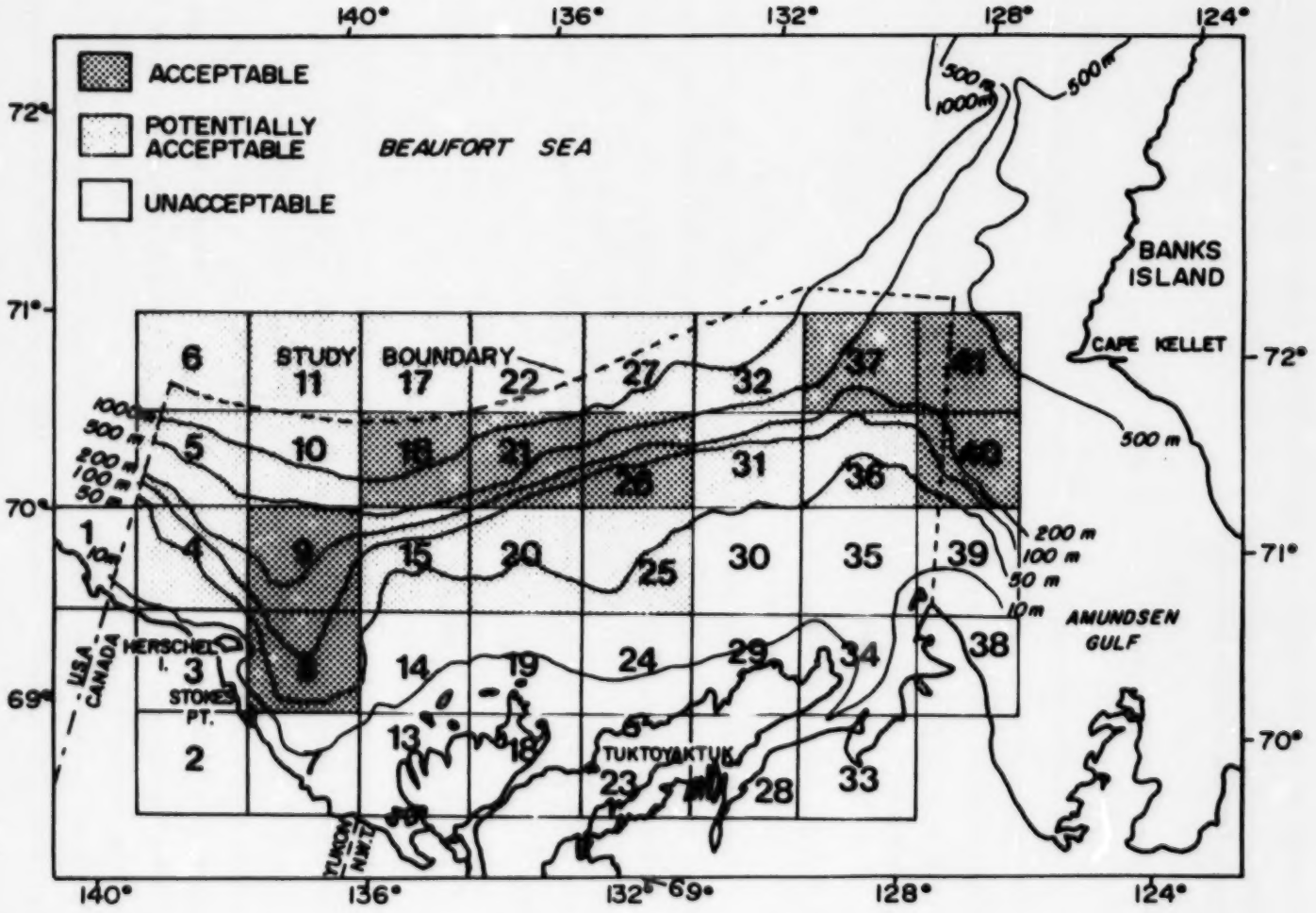

Figure 6. Dumpsite designation blocks as determined by the decision matrix.

implicit considerations involved in the evaluation of blocks where water depths were generally less than 50 m.

Eight blocks were classified as being "Acceptable" as potential disposal areas: 8, 9, 16, 21, 26, 37, 40 and 41. A further fourteen blocks were considered "Potentially Acceptable": 4-6, 10, 11, 15, 17, 20, 22, 25, 27, 31, 32 and 36. The primary criteria leading to the designation of a block as "Potentially Acceptable" rather than "Acceptable" were: (1) shallow water (< 50 m) over much of its area, or (2) probable limited access in some months or years due to the ice regime. The remaining blocks (1-3, 7, 13, 14, 18, 19, 23, 24, 28-30, 33-35, 38 and 39) were considered "Unacceptable" for one or more of the reasons described above.

6.3 Analysis of Economic Constraints

The economics of bulky inert waste disposal in the Beaufort Sea were evaluated through consideration of the shipping distance between waste stockpiling sites and "Acceptable" and "Potentially Acceptable" ocean disposal blocks determined from the previous analysis. This was accomplished by plotting a series of concentric distance circles at 50 km intervals from a point 50 km north of Tuktoyaktuk (off Pullen Island) and from King Point on the Yukon coast, the assumed locations of material requiring ocean disposal (see Figures 7 and 8, respectively). Distances to the centre of each "Acceptable" and "Potentially Acceptable" block were determined by assuming a direct voyage to the ocean disposal area. The average of the distances from Tuktoyaktuk and King Point was also determined for each block for comparative purposes. Finally, the cost of the round trip to each block from the two shorebases was calculated by assuming a base cost of $21,000 per trip, plus $7,000 per 50-km round trip voyage segment. The results of this analysis are presented in Table 2.

For wastes stockpiled at Tuktoyaktuk, the closest "Acceptable" ocean disposal areas would be located approximately 160 km away in either Block 21 or 26, although two "Potentially Acceptable" areas are located somewhat closer in Blocks 20 (120 km) and 25 (115 km). As indicated by the information provided in Appendix 1, the northern, deeper portions of either Block 20 or 25 have no constraints to their selection as ocean disposal areas. The approximate cost per trip to the "Acceptable" blocks is estimated at $43,000, and would be decreased to $37,000 - 38,000 if one of the "Potentially Acceptable" ocean disposal areas was ultimately selected.

The closest "Acceptable" disposal area from King Point is Block 8, which is located only 50 km to the NNE from this site on the Yukon coast. Several other

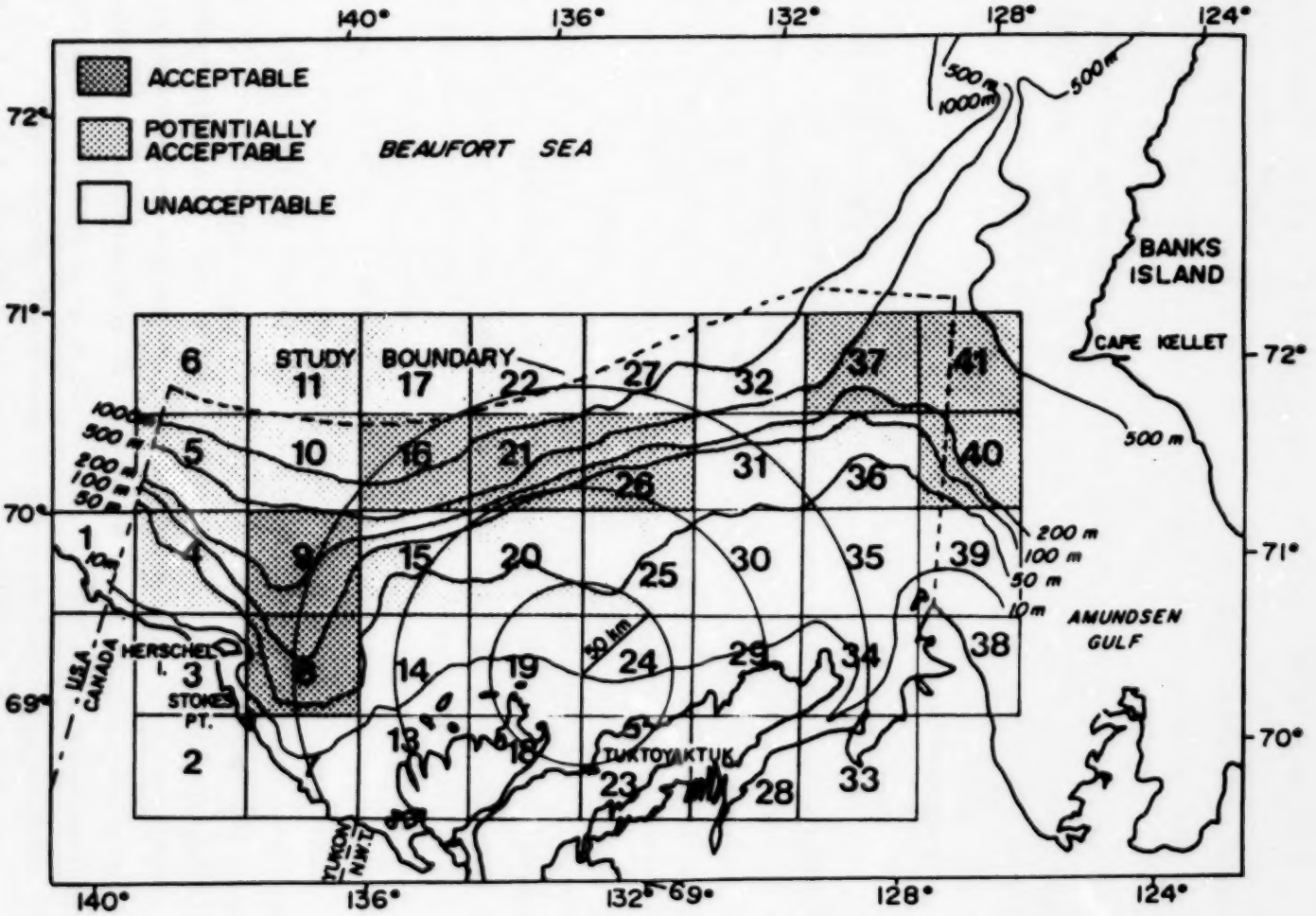

Figure 7. Distances from 50 km due north of Tuktoyaktuk to dumpsite designation blocks rated as "acceptable" or "potentially acceptable".

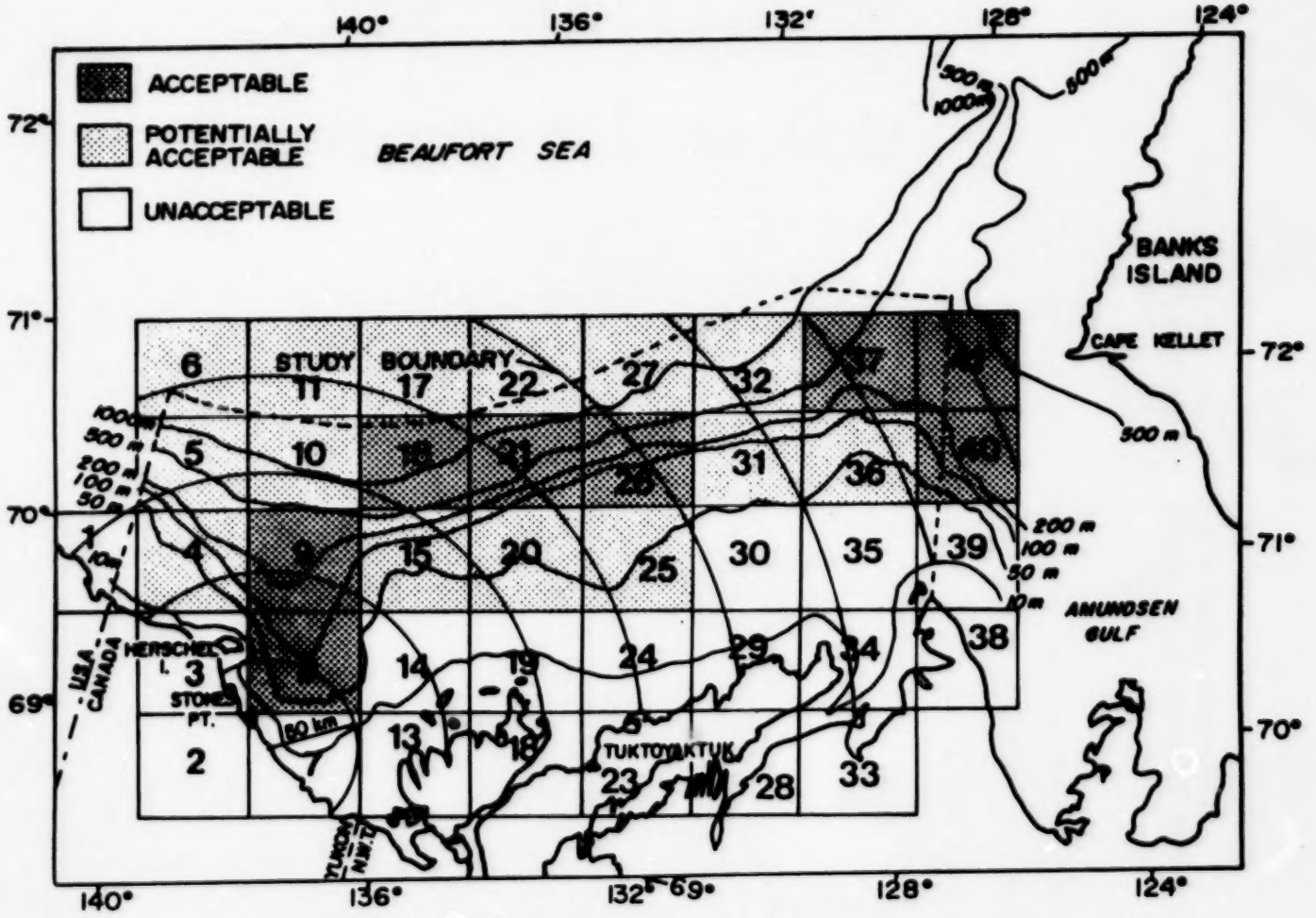

Figure 8. Distances from King Point to dumpsite designation blocks rated as "acceptable" or "potentially acceptable".

Table 2.

Approximate Distances and Transport Costs to the Centre of Blocks Designated as "Acceptable (A)" and "Potentially Acceptable (P)" from Tuktoyaktuk and King Point

Block	Designation	Tuk (km)	King (km)	Average (km)	Tuk ($K)	King ($K)
8	A	200	50	125	49K	28K
9	A	210	110	160	50K	36K
16	A	185	170	178	47K	45K
21	A	160	205	183	43K	50K
26	A	160	245	203	43K	55K
37	A	255	355	305	57K	71K
40	A	265	60	313	58K	71K
41	A	280	395	338	60K	76K
4	P	260	115	188	57K	37K
5	P	270	155	213	59K	43K
6	P	295	210	253	62K	50K
10	P	225	155	190	53K	43K
11	P	260	205	233	57K	50K
15	P	160	125	143	43K	39K
17	P	160	220	190	43K	52K
20	P	120	170	145	38K	45K
22	P	220	245	233	52K	55K
25	P	115	220	168	37K	52K
27	P	205	275	240	50K	60K
31	P	185	285	235	47K	61K
32	P	225	315	270	53K	65K
36	P	225	330	278	53K	67K

"Acceptable" (Blocks 9 and 16) and "Potentially Acceptable" (Block 4, 5, 10, 15 and 20) areas are also located within 170 km of King Point. Depending on which area is selected for ocean disposal, the round-trip costs to the blocks indicated above would range from about $28,000 to $45,000.

From an economic perspective, therefore, it would be beneficial to select two ocean disposal areas from the "Acceptable" or "Potentially Acceptable" blocks described earlier in this report. The obvious choices would be either Block 21 or 26 (or northern portions of Blocks 20 or 25) to receive wastes from Tuktoyaktuk, and Block 8 for inert solids stored at King Point. In the event that this is not practical or desirable for other reasons, it is evident from the average distances presented in Table 2, that several blocks are within reasonable reach of both Tuktoyaktuk and King Point. Of the areas designated as "Acceptable", these include Blocks 8, 9 16, 21 and perhaps 26. Consideration could also be given to selection of a single area in a deeper portion of Block 15, 20 or 25. Any of these alternatives would tend to minimize the costs associated with transport of inert bulky wastes from the two assumed stockpile locations in the Beaufort region.

7.0 PREFERRED SITES

On the basis of the present analysis of non-economic and economic constraints associated with selection of ocean disposal areas for inert bulky wastes in the Beaufort Sea, it would appear that selection of two areas would be most financially acceptable and still pose limited environmental concerns or conflicts with other activities in the region. For wastes originating from or stockpiled at Tuktoyaktuk, either block 21 or 26 would be most suitable, while block 8 is the closest "Acceptable" area to King Point. As evident from Figure 3, most areas within blocks 21 and 26 are characterized by water depths in excess of 100 m, and both are located outside the primary zone of industry activity in the region. On the other hand, ocean dumping in block 8 may have to be scheduled to avoid conflicts with (1) marine transport activities between the Yukon coast and areas north of Tuktoyaktuk Peninsula, and (2) congregations of bowhead whales during some periods (particularly late August and September).

If only one ocean dumping area is to be selected for the entire Beaufort region, Blocks 9 and 16 could be considered in addition to any of the above three areas (Blocks 8, 21 and 26). All of these have been designated as "Acceptable", although timing restrictions may again be necessary in Blocks 8 and 9 to avoid conflicts with marine transport and bowhead whale feeding and migration off the Yukon coast. Depending on the volume of solid wastes to be transported from Tuktoyaktuk relative to that from King Point, it may be appropriate to consider selection of a single ocean dumping area in the northern portion of either Block 20 or 25, where water depths exceed 50 m. If most of the bulky inert wastes are expected to originate from Tuktoyaktuk, the shorter travel distance to these blocks could reduce the cost of a round trip by $7,000 - 10,000 and still have few physical, biological or operational constraints.

8.0 PHYSICAL AND BIOLOGICAL CHARACTERIZATION OF SELECTED OCEAN DISPOSAL AREA(S)

It is recommended that a study be conducted to characterize the physical and biological environmental characteristics of any of the "Acceptable" or "Potentially Acceptable" areas considered further for ocean dumping of inert wastes in the Beaufort Sea. This research is considered necessary because of the lack of site-specific data in almost all offshore areas of the Beaufort, and will provide the baseline for comparison of pre- and post-dumping environmental conditions and quantification of the actual impact of ocean dumping.

8.1.1 Biological Data

As indicated in previous sections, the primary biological resources affected by ocean dumping are benthic communities and, to a lesser extent, the organisms that prey on these species. As a result, the biological component of pre-dumping surveys should focus on characterization of the benthic community. Site-specific information should be obtained on the species composition, and, if feasible, the abundance or biomass of infaunal and epifaunal benthic invertebrates. In addition, samples of demersal fish species should be obtained from the area or areas of possible waste disposal to assess, in a qualitative manner, the fish that could be indirectly affected by disposal of wastes and subsequent increased microrelief and possible shelter. Biological sampling methods could include use of grab samplers, trawls, traps and possibly underwater video.

8.1.2 Oceanographic Data

In offshore areas of the Beaufort Sea beyond the depth of ice scour, bottom currents are the primary factor that could influence the subsequent re-distribution of solid wastes reaching the seafloor, as well as movements of sediments in areas of waste deposition. Therefore, it is considered important to determine the direction and velocity of bottom currents in areas that may be selected for ocean disposal. It is also important that currents be measured during the period when their magnitude is expected to be greatest (i.e., open water season) and over a sufficient time period to assess the potential for movement of wastes or alteration of normal sediment dispersal patterns.

8.1.3 Geological Parameters

It is considered important to obtain accurate measurements of water depths in the vicinity of potential ocean disposal areas to produce the accurate bathymetric charts necessary to evaluate local variations in topographic features, particularly steep slopes and other features that could lead to widespread distribution of wastes reaching the seafloor. Such measurements in conjunction with side-scan sonar studies would also document areas of ice scour, the distribution of surficial sediments, slumping and other geological features in possible ocean disposal areas. In addition, the collection of sediment cores would be useful to determine the particle size distribution of surficial sediments in the area, as well as the possible presence of permafrost layers which could lead to sediment instability and slumping.

9.0 ENVIRONMENTAL MONITORING

Despite the anticipated local and regional insignificance of the ocean dumping of inert bulky wastes on the marine environment, there may be considerable scientific merit in the initiation of a monitoring program to document the impact of disposal and the rates at which new hard substrate is exploited as new habitat and cover by benthic organisms and demersal fish.

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APPENDIX 1.

Rating Designation of Grid Blocks

APPENDIX 1

Rating Designation of Grid Blocks (see Figure 5)

(* U = unacceptable;
P = potentially unacceptable;
A = acceptable.)

Block	Designation*	Rationale
1	U	- area of potential ice scouring - potential marine park site - marine navigation zone - area of oil and gas exploration - potential anadromous fish harvesting
2	U	- area of potential ice scouring - marine navigation zone - area of oil and gas exploration - potential anadromous fish harvesting
3	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - marine navigation zone - area of oil and gas exploration - potential anadromous fish harvesting
4	P	- northeast portion has no constraints - southwest portion: - area of potential ice scouring - marine navigation zone - area of oil and gas exploration
5	P	- access through ice is a constraint
6	P	- access through ice is a constraint

Block	Designation*	Rationale
7	U	- some biological sensitivity - area of potential ice scouring - potential marine park site - marine navigation zone - area of oil and gas exploration - anadromous fish harvesting
8	A	- no constraints (except in extreme southwest in water depths shallower than 50 m)
9	A	- no constraints
10	P	- access through ice is a constraint
11	P	- access through ice is a constraint
13	U	- some biological sensitivity (white whale, anadromous fish) - area of potential ice scouring - marine navigation zone - area of oil and gas exploration - white whale and anadromous fish harvesting
14	U	- some biological sensitivity (white whale, anadromous fish) - area of potential ice scouring - marine navigation zone - area of oil and gas exploration - white whale and anadromous fish harvesting

Block	Designation*	Rationale

15	P	- northern and extreme southwest portions have no constraints
		- remainder of area:
		  - area of potential ice scouring
		  - marine navigation zone
		  - area of oil and gas exploration

16	A	- no constraints
17	P	- no constraints - access through ice is a potential constraint
18	U	- biological sensitivity - area of potential ice scouring - potential marine conservation area - potential "National Landmark" area - marine navigation zone - area of oil and gas exploration
19	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - marine navigation zone - area of oil and gas exploration

20	P	- northern portion has no constraints
		- southern portion:
		  - area of potential ice scouring
		  - marine navigation zone
		  - area of oil and gas exploration

21	A	- no constraints
22	P	- access through ice is a potential constraint

Block	Designation*	Rationale
23	U	- some biological sensitivity - area of potential ice scouring - potential "National Landmark" area - marine navigation zone - area of oil and gas exploration
24	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - marine navigation zone - area of oil and gas exploration

25	P	- northwest portion has no constraints
		- southeast portion:
		  - area of potential ice scouring
		  - area having pingo-like features
		  - possible area of "National Significance"
		  - marine navigation zone
		  - area of oil and gas exploration

26	A	- no constraints
27	P	- access through ice is a potential constraint
28	U	- some biological sensitivity - area of potential ice scouring - possible "National Landmark" site - marine navigation zone
29	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - marine navigation zone - area of oil and gas exploration

Block	Designation*	Rationale
30	U	- some biological sensitivity - area of potential ice scouring - area having pingo-like features - possible area of "National Significance" - marine navigation zone - area of oil and gas exploration
31	P	- area having pingo-like features - possible area of "National Significance" - area of oil and gas exploration
32	P	- access through ice is a potential constraint
33	U	- some biological sensitivity - area of potential ice scouring - possible "National Landmark" site - marine navigation zone
34	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - marine navigation zone - area of oil and gas exploration
35	U	- some biological sensitivity - area of potential ice scouring - borrow pit area - area having pingo-like features - possible area of "National Significance" - marine navigation zone - area of oil and gas exploration

Block	Designation*	Rationale

36	P	- northern portion has no constraints
		- southeast portion:
		  - area having pingo-like features
		  - possible area of "National Significance"
		  - marine navigation zone
		  - area of oil and gas exploration

37	A	- no constraints
38	U	- some biological sensitivity - area of potential ice scouring - potential "National Landmark" area - marine navigation zone
39	U	- some biological sensitivity - area of potential ice scouring - marine navigation zone - area of oil and gas exploration
40	A	- no constraints (except in extreme southwest corner where less than 50 m)
41	A	- no constraints